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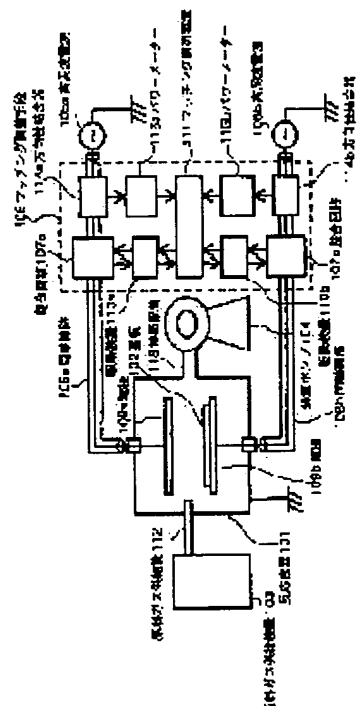
(54) METHOD AND APPARATUS FOR VACUUM TREATMENT

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a method for vacuum treatment, which can improve operability for matching adjustment, and reproducibility of the matching condition, and shorten adjusting time for matching, when performing vacuum treatment while applying several high-frequency powers at the same time, and provide an apparatus for vacuum treatment.

SOLUTION: In the method for vacuum treatment, which mounts a substrate to be treated 102 in a reaction vessel 101 capable of being depressurized, introduces a source gas, generates plasma of the source gas by a high-frequency power, and treats the substrate to be treated, this method is characterized by supplying several high-frequency powers to an electrode 109a through matching circuits 107a and 107b, detecting at least either the state of the several matching circuits or the matching state of the high-frequency power, and adjusting the several matching circuits with a matching control circuit 111 through feeding back the detected results.



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* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] In the vacuum art which installs a processed material in the reaction container which can be decompressed, introduces material gas in said reaction container, generates the plasma of this material gas and processes said processed material with the impressed high-frequency power The vacuum art which supplies two or more high-frequency power to an electrode through a separate matching circuit, and is characterized by the thing of the condition of each matching circuit, and the matching condition of each high-frequency power for which it detects at least any they are, a mutual detection result is fed back, and said two or more matching circuits are adjusted.
[Claim 2] The vacuum art according to claim 1 characterized by supplying said two or more high-frequency power to the same electrode.
[Claim 3] The vacuum art according to claim 1 or 2 characterized by detecting the condition of said matching circuit by the setups of the variable reactance of this matching circuit.
[Claim 4] A vacuum art given in any 1 term of claims 1-3 characterized by detecting said matching condition with reflective power.
[Claim 5] The phase of a reflected wave [as opposed to an incident wave for said matching condition], and a vacuum art given in any 1 term of claims 1-3 characterized by the thing of the amplitude of a reflected wave detected by any they are at least.
[Claim 6] As for said two or more high-frequency power, a frequency contains 10MHz or more at least two high-frequency power 250MHz or less. About the high-frequency power which has the largest frequency in the frequency which the high-frequency power in this frequency range has, and a frequency large next Among those, a vacuum art given in any 1 term of claims 1-5 with which the relation of said frequencies f1 and f2 fills the conditions of f1/f2 <=10 when the frequency of high-frequency power with lower f1 and a lower frequency is set to f2 for the frequency of high-frequency power with a higher frequency.
[Claim 7] In the vacuum processor equipped with the reaction container which can be decompressed, a means to install a processed material in this reaction container, a means to supply material gas to this reaction container, and a RF electric power supply means to make this material gas generate the plasma Two or more matching circuits where this RF electric power supply means carries out matching adjustment of the high-frequency power outputted from two or more RF generators and these two or more RF generators separately, The vacuum processor characterized by having a means of the condition of two or more of these matching circuits, and the matching condition of high-frequency power to detect at least any they are, and a matching adjustment means to feed back a mutual detection result and to adjust two or more matching circuits.
[Claim 8] The vacuum processor according to claim 7 characterized by connecting said two or more RF generators to the same electrode.
[Claim 9] The vacuum processor according to claim 7 or 8 characterized by a means to detect the condition of said matching circuit being a means to detect the setups of the variable reactance in a matching circuit.
[Claim 10] A vacuum processor given in any 1 term of claims 7-9 characterized by a means to detect said matching condition being a means to detect reflective power.
[Claim 11] A vacuum processor given in any 1 term of claims 7-9 to which a means to detect said matching condition is characterized by being a means of the phase of the reflected wave to an incident wave, and the amplitude of a reflected wave to detect at least any they are.
[Claim 12]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the vacuum processor using high-frequency power used for deposition film formation, etching, etc. in a semiconductor device, the photo conductor for electrophotography, the line sensor for an image input, a photography device, a photoelectromotive-force device, etc., and a vacuum art.
[0002]
[Description of the Prior Art] The vacuum art using the plasma generated by high-frequency power, such as a plasma-CVD method, the ion plating method, and the plasma-etching method, is known by the vacuum art used in order to form a semiconductor device, the photo conductor for electrophotography, an image input line sensor, a photography device, a photoelectromotive-force device, etc. conventionally, and many of the equipment is also put in practical use.
[0003] For example, the deposition film formation approach using a plasma-CVD method is the approach of forming the deposition film by the glow discharge of high-frequency power generating the plasma of material gas, and making the decomposition kind deposit on a substrate. It is possible by using silane gas for material gas, when this approach is used to form an amorphous silicon (a-Si) thin film. Moreover, in recent years, a deposition film formation rate is quick, and the plasma-CVD method using the high-frequency power of the VHF band with which the quality deposition film is obtained attracts attention.
[0004] By the above-mentioned approach, deposition film formation which reconciled improvement in a deposition film formation rate and quality improvement of the deposition film can be performed. However, the demand level of the commercial scene over a product is increasing every day, and the vacuum art which can produce the product of high quality, the deposition film formation approach, and equipment are called for.
[0005] For example, since not only an alphabetic character manuscript but the copy of a photograph etc. is made [in / the case of the photo conductor for electrophotography / digital electrophotography equipment with the remarkable spread, or color electrophotography equipment] frequently, more than before, the demand to high-definition-izing is becoming severe, and reduction of image concentration unevenness is called for especially in recent years more strongly than before. Therefore, forming the deposition film with thickness and membraneous quality still more uniform than before on the base of not only quality improvement of the deposition film but a large area is called for. Moreover, it is quality, and after [which the demand to low-cost-izing is also becoming still severer, and was described previously] realizing thickness and the uniform deposition film of membraneous quality, it is also necessary to raise a deposition film formation rate further.
[0006] For example, high-frequency voltage with a low frequency [of 100kHz] and a high frequency of 13.56MHz is impressed to coincidence between parallel plates as the membraneous quality of the deposition film, and the plasma vapor growth approach which especially controls internal stress, and the approach of controlling internal stress by the voltage ratio is learned.
[0007] However, the time amount which each influences each other through the plasma in order that each matching circuit may ask coincidence for the point having consistency, when plasma fluctuation arises by flow rate fluctuation of material gas, since it is combined by the plasma which high-frequency voltage generates between parallel plates through each matching circuit with the above-mentioned approach, and becomes unstable [the plasma] became long, and the controllability of internal stress and repeatability were low.
[0008] As a means for solving such a problem, the method of repeating each high-frequency voltage to an electrode successively, and impressing it to it intermittently, is indicated in the ****** No. 2734021 official report. To be sure, the repeatability of the plasma can be improved by this approach.
[0009]
[Problem(s) to be Solved by the Invention] However, in order to improve the heterogeneity of the vacuum processing resulting from a standing wave in the vacuum processing using high-frequency power with a comparatively high

frequency When making two or more high-frequency power superimpose, Or in order to acquire the bias effectiveness, two or more high-frequency power can be supplied to an electrode at coincidence, it is necessary to perform vacuum processing, and the above-mentioned approach cannot be used a case [high-frequency power with a comparatively low frequency being made to superimpose on high-frequency power with a comparatively high frequency].
[0010] This invention aims at solution of the above-mentioned technical problem. Namely, a processed material installs into a reaction container and high-frequency power decomposes the material gas which supplied in the reaction container, and in case two or more high-frequency power supplies to an electrode through each matching adjustment means, it aims at providing a vacuum processor and a vacuum art realizable in improvement in the operability of matching adjustment, improvement in the repeatability of matching adjustment, and compaction of the time amount to matching adjustment in the vacuum processing which processes to the processed material.
[0011]
[Means for Solving the Problem] In the vacuum art which the vacuum art of this invention installs a processed material in the reaction container which can be decompressed, and introduces material gas, generates the plasma of the material gas and processes the processed material with the impressed high-frequency power Two or more high-frequency power is supplied to an electrode through a separate matching circuit, and it is characterized by the thing of the condition of each matching circuit, and the matching condition of each high-frequency power for which it detects at least any they are, a mutual detection result is fed back, and each matching circuit is adjusted.
[0012] First, in this invention of a configuration of supplying the high-frequency power outputted from two or more RF generators to a reaction container through a separate matching circuit, the high-frequency power with which the frequencies outputted from two or more RF generators differ interacts through the plasma at least. Therefore, adjustment of one matching circuit may influence matching of other high-frequency power. The load at the time of seeing this from one RF generator is because it connects in [the matching circuit of another side, and the RF generator of another side] serial the matching circuit of the RF generator, an electrode, and not only the plasma but through the plasma further.
[0013] Then, more suitable matching adjustment is attained by adjusting the matching circuit of another side, detecting the condition of one matching circuit.
[0014] The matching adjustment means which consists of a driving gear for changing a setup of two or more matching circuits and a matching circuit as a concrete matching adjustment means and a matching control device which detects the setups of a driving gear and performs matching adjustment is mentioned. When using such a matching adjustment means, the motor of a driving gear performs matching adjustment as a configuration to which the capacity of the variable ceramic capacitor in a matching circuit is changed. Therefore, the condition of a matching circuit is detectable by the operating state of this motor, angle of rotation of a motor, the motor control parameter in a control device, the capacity of a variable ceramic capacitor, etc. Matching can be smoothly adjusted by a matching control unit's detecting the condition of the mutual matching circuit detected by the above-mentioned approach, and adjusting the matching circuit of another side based on a detection result.
[0015] Moreover, more suitable matching adjustment can be performed by detecting the matching condition of each high-frequency power, and performing matching adjustment based on the detection result. Although it is desirable that it is completely independent and adjustment of the high-frequency power with which the frequencies outputted from each RF generator differ fundamentally can be adjusted, suitable matching adjustment can be performed by adjusting each matching circuit, detecting a mutual matching condition, since an interaction occurs as mentioned above in fact.
[0016] Furthermore, this invention is especially effective in the configuration which supplies two or more high-frequency power to the same electrode. Since direct continuation of the matching circuit of each high-frequency power is carried out through the electrode and the high-frequency power other than the interaction through plasma which was mentioned above carries out a direct interaction when supplying two or more high-frequency power to the same electrode, actuation of one matching circuit does effect strong against matching of another side. Therefore, in the configuration which supplies two or more high-frequency power to the same electrode, the effectiveness of this invention can be acquired notably.
[0017] Furthermore, as for detection of the condition of the matching circuit mentioned above, it is desirable to detect the reactance conditions of a matching circuit. When the output impedance of an RF generator is R+jX and the input impedance by the side of a load, i.e., a fission reactor, is R-jX, matching is adjusted and maximum electric power is supplied to a load side. That is, by detecting the reactance conditions of a matching circuit, since an input impedance can be grasped and the condition of a matching circuit can be detected more correctly, it is desirable.
[0018] Moreover, it is desirable to detect the reflective power of each high-frequency power as an approach of detecting the matching condition mentioned above. In a low frequency circuit, generally a high input impedance and a low-power output impedance are bases, and an electrical-potential-difference value can estimate the reinforcement of a reflected wave. On the other hand, in order to take adjustment of I/O, a constant input impedance and a constant output

impedance are bases, and it is desirable to evaluate the reinforcement of a reflected wave by the power value in a RF circuit. Therefore, it is desirable to evaluate the condition of matching by this invention using high-frequency power with a reflective power value.

[0019] Moreover, the thing of the phase of the reflected wave to the incident wave of each high-frequency power and the amplitude of a reflected wave for which it detects at least any they are is desirable as an approach of detecting a matching condition. This can judge whether the conductance component or inductance component of a reactance of a matching circuit should be adjusted by detecting the phase of the reflected wave to an incident wave. Moreover, by detecting the amplitude of a reflected wave, the amount of adjustments can be determined and more suitable matching adjustment can be performed.

[0020] Furthermore, in this invention, when the frequency of two high-frequency power with a large output among two or more high-frequency power to be used is set to f1 and f2, the effectiveness of this invention is notably acquired in 10MHz<=f2<f1 <=250MHz and f1/f2 <=10. In the above-mentioned range where a frequency is comparatively near, a matching adjustment means tends to do effect mutually, and the effectiveness of this invention can be acquired notably.

[0021]

[Embodiment of the Invention] Drawing 1 shows the mimetic diagram of the parallel monotonous plasma treatment equipment which applied this invention and which is the gestalt of the 1st operation. The equipment of drawing 1 is equipped with the reaction container 101 with which the substrate 102 which is a processed material is installed and which can be decompressed, the material gas feeder 103 which introduces material gas in the reaction container 101, the exhaust air pump 104 which exhausts the inside of the reaction container 101, two RF generators 105a and 105b, and matching adjustment means 106.

[0022] With the gestalt of this operation, two high-frequency power with which frequencies differ minds the separate matching circuits 107a and 107b from each RF generators 105a and 105b. Two driving gears 110a and 110b which are the configurations supplied to the separate electrodes 109a and 109b, and change the setups of each matching circuits 107a and 107b, The conditions of each driving gears 110a and 110b, Or detected the conditions of matching circuit 107a and the 107b itself, have the matching control device 111 into which a detection result is inputted, and a mutual detection result is fed back also to matching adjustment actuation of another side. He is trying for the matching control unit 111 to adjust both matching circuits 107a and 107b. Matching circuits 107a and 107b consist of a variable ceramic capacitor, a variable inductance, variable resistance, etc., and, specifically, the configuration which drives each variable ceramic capacitor, a variable inductance, variable resistance, etc. by a motor etc. is mentioned as driving gears 110a and 110b. For example, if the relation between the setting include angle of a motor and the electrostatic capacity of a variable ceramic capacitor is determined when driving a variable ceramic capacitor by the motor, the electrostatic capacity of a variable ceramic capacitor is detectable by detecting the setting include angle of a motor. Moreover, if the relation between angle of rotation of a motor and the rate of change of the electrostatic capacity of a variable ceramic capacitor is determined, a changed part of the electrostatic capacity of a variable ceramic capacitor is also detectable by detecting angle of rotation of a motor. Or by detecting the drive condition of a motor, the change condition of the capacity of a variable ceramic capacitor can be detected, and the standard of matching adjustment conditions can also be defined. For example, while making it a setup to which change of matching circuit 107b of another side is not carried out while changing one matching circuit 107a or fulfilling some conditions, it is also possible to control by the matching control unit 111 with setting modification of one matching circuit 107a to change a setup of matching circuit 107b of another side. Moreover, a constant rate or when rate change of a constant ratio is carried out, according to the variation and rate of change, the electrostatic capacity of the variable ceramic capacitor in matching circuit 107b of another side can also be changed for the electrostatic capacity of the variable ceramic capacitor in one matching circuit 107a. The approach explained here is applicable also to a variable inductance and control of variable resistance.

[0023] Furthermore, with the equipment of drawing 1 , it has a means to detect reflective power and has composition which feeds back the detection result to the matching control device 111.

[0024] the configuration taken out as a voltage signal proportional to reflective power that what is necessary is for detection of reflective power to insert directional couplers 114a and 114b among each RF generators 105a and 105b and matching circuits 107a and 107b, and just to be able to detect even the power of the reflected wave taken out with known degree of coupling -- or the approach of detecting with power meters 115a and 115b is mentioned. In this way, by making the value of the detected reflective power the configuration inputted into the matching control unit 111, change of the reflective power of another side accompanying adjustment of one matching circuit becomes detectable, and the matching adjustment approach of one matching circuit can be determined. For example, when the reflective power of another side detected by power meter 115b goes up with adjustment of one matching circuit 107a, it is made a setup which suspends adjustment of one matching circuit 107a, or it is made a setup which will continue adjustment if it is below default value with the reflective power of another side, and an approach which is made to perform matching

adjustment is mentioned.
[0025] In addition, although not shown in drawing 1 , are lower than f1 to the 1st RF generator (oscillation frequency: f1 (> f2)). A high-pass filter with cut-off frequency characteristics higher than f2 is prepared. To the 2nd RF generator (oscillation frequency: f2), it is higher than f2 similarly, and it is more desirable to prepare a low pass filter with cut-off frequency characteristics lower than f1, and to make it a configuration which makes small power of another side which turns to each RF generator.
[0026] Next, drawing 2 is the gestalt of the 2nd operation which applied this invention, and shows the mimetic diagram of the same parallel monotonous plasma treatment equipment as drawing 1 . The difference from the gestalt of the 1st operation is in the configuration which supplies each high-frequency power outputted from two RF generators 205a and 205b to the same electrode 209 through each matching circuits 207a and 207b with the equipment of drawing 2 .
[0027] Moreover, drawing 3 shows the mimetic diagram of the deposition film formation equipment which applied this invention and which is the gestalt of the 3rd operation. Drawing 4 is the A-A' sectional view of drawing 3 .
[0028] The deposition film formation equipment of the gestalt of this operation is equipment which forms the deposition film in the cylindrical base 302, and is equipped with RF generators 305a and 305b which introduce power into the reaction container 301 of the shape of a cylinder which can be decompressed, the material gas supply pipe 312 which introduces desired material gas, RF electrode 309 which introduces power in the reaction container 301, and RF electrode 309, and the matching adjustment means 306.
[0029] An exhaust pipe arrangement 313 is formed in the base of the reaction container 301 in one, and the other end of an exhaust pipe arrangement 313 is connected to the exhaust air pump 304. One cylindrical base 302 with which the deposition film is formed in the core of the reaction container 301 is arranged. The cylindrical base 302 is in the condition installed in the base base material 316, is held with a revolving shaft 317, and is heated with a heating element (un-illustrating). If a motor 319 is driven, a revolving shaft 317 will rotate through the moderation gear 318, and the cylindrical base 302 will rotate the surroundings of the direction medial axis of a bus-bar.
[0030] It connects with the material gas feeder 303, and the material gas supply pipe 312 has composition which can supply the material gas of requests, such as SiH_4, H_2, GeH_4, and B-2s H6, PH_3, CH_4, NO, Ar, and helium, by the desired flow rate.
[0031] In drawing 3 , high-frequency power is compounded through matching circuits 307a and 307b from two RF generators 305a and 305b, and is supplied in the reaction container 301 from RF electrode 309 through the power branching plate 320.
[0032] Furthermore, in drawing 3 , it has composition using the reflected wave meter 315a and 315b which can detect the phase to the incident wave of a reflected wave, or/and the amplitude of a reflected wave as a means to detect a matching adjustment condition. Like the case of a power meter, directional couplers 314a and 314b are inserted among each RF generators 305a and 305b and matching circuits 307a and 307b, and about the incident wave and reflected wave which were taken out with known degree of coupling, the phase of an incident wave and a reflected wave or/and the amplitude of a reflected wave are detected, and it is considering as the configuration which inputs a detection result into the matching control unit 311. With such a configuration, the phase change of the incident wave of another side accompanying adjustment of one matching circuit and a reflected wave or/and amplitude change of a reflected wave are detected, and the matching control device 311 is made to perform matching adjustment based on the result.
[0033] Furthermore, drawing 5 shows the mimetic diagram of the deposition film formation equipment of the gestalt of the 4th operation which applied this invention. Drawing 6 is the A-A" sectional view of drawing 5 . The material gas supply pipe 412 is installed centering on the inside of the reaction container 401, and, as for the difference between the equipment of drawing 5 , and the equipment of drawing 3 , two or more cylindrical bases 402 are installed by regular intervals in the reaction container 401 on the periphery centering on the material gas supply pipe 412. Moreover, some reaction containers [at least] 401 consist of dielectric materials, and RF electrode 409 is installed in the outside of the reaction container 401, and it has the composition that the RF shielding container 421 is formed in the outside.
[0034] As dielectric materials which constitute some reaction containers 401, a ceramic ingredient is desirable, and, specifically, an alumina, a titanium dioxide, alumimium nitride, boron nitride, zircon, cordierite, zircon-cordierite, oxidization silicon, the beryllium oxide mica system ceramics, etc. are mentioned. Furthermore, as for the field exposed to the plasma of a reaction container, it is desirable to be split-face-ized from the purpose which improves membranous adhesion, prevents film peeling and controls the dust under membrane formation. As concrete extent of split-face-izing, the 5-micrometer or more range of 200 micrometers or less is desirable at the ten-point average of roughness height (Rz) on the basis of 2.5mm.
[0035] for example, the deposition film for a cylinder-like electrophotography photo conductor -- the equipments with above formation -- using -- an outline -- the following procedures can perform. The example which used the equipment of drawing 3 for below is explained.
[0036] First, the cylindrical base 302 is installed in the reaction container 301, and the inside of the reaction container

301 is exhausted through an exhaust pipe arrangement 313 with the exhaust air pump 304. Then, it sets up so that inert gas, such as Ar gas, may be introduced in the reaction container 301, the amount of supply and exhaust velocity of gas may be adjusted through the material gas supply pipe 312 and the inside of the reaction container 301 may become a fixed pressure by the material gas feeder 303. Next, the cylindrical base 302 is heated and controlled by the heating element (un-illustrating) at the predetermined temperature of 200 degrees C - about 300 degrees C, and it maintains until temperature is stabilized.

[0037] After exhausting enough the inert gas used for heating, in the place where the cylindrical base 302 became predetermined temperature, material gas is introduced in the reaction container 301 through the material gas supply pipe 312 by the material gas feeder 303. After checking that the flow rate of material gas turned into a setting flow rate, and the pressure in the reaction container 301 has been stabilized, After supplying power to RF electrode 309 through matching circuit 307a and starting glow discharge in the reaction container 301 from RF generator 305a, Occurring the plasma which supplied power to RF electrode 309 through matching circuit 307b, and was stabilized in the reaction container 301 from RF generator 307b of another frequency, material gas carries out excitation dissociation and forms the deposition film on the cylindrical base 302.

[0038] Furthermore, what is necessary is to change a class, each flow rate, etc. of material gas into a predetermined value, and just to form the next layer field, after forming the layer field of request thickness in order to obtain the deposition film of multilayer structure. For example, the photo conductor for electrophotography is formed by depositing on a base in order of a charge impregnation blocking layer, a photoconduction layer, and a surface layer.

[0039] In the above-mentioned approach, while maintaining the time of initiation of glow discharge, and the plasma, the matching control unit 311 carries out matching adjustment, feeding back the effect accompanying adjustment of the mutual matching circuits 307a and 307b to matching adjustment of another side while adjusting matching of the high-frequency power which corresponded by adjusting matching circuits 307a and 307b.

[0040] Specifically, each matching circuits 307a and 307b are adjusted, supervising the condition of each matching circuits 307a and 307b. For example, impedance change seen from the RF generator 305b side of another side by adjusting one matching circuit 307a is detected, and another matching circuit 307b is adjusted. In others, while adjusting one matching circuit 307a, adjustment of matching circuit 307b of another side is not performed. Or it is made to adjust matching circuit 307b of another side to the bottom of a certain condition.

[0041] Furthermore, each matching circuits 307a and 307b are adjusted, supervising the matching condition of each high-frequency power. For example, the behavior of the phase to the incident wave of the reflected wave detected in the reflected wave meter 315b and 315a of the reflective power of the high-frequency power of another side accompanying one matching circuit 307a and 307b adjustment and the amplitude of a reflected wave is supervised, and each matching circuits 307a and 307b are adjusted so that matching of both high-frequency power can be taken. In this way, the stable discharge is maintained and the deposition film is formed.

[The example of an experiment]

(Example 1 of an experiment) In this example of an experiment, the discharge experiment was conducted 30 times on condition that Table 1 using the equipment of drawing 1 . The motor by which the matching adjustment means 106 of the equipment of drawing 1 controls matching circuits 107a and 107b and matching circuits 107a and 107b, The driving gears 110a and 110b which can detect the operating state of a motor, each RF generators 105a and 105b, The directional couplers 114a and 114b inserted between RF generators 105a and 105b and matching circuits 107a and 107b, It consists of matching control units 111 which feed back the detection result of power meters 115a and 115b and power meters 115a and 115b which detects the reflective power outputted from directional couplers 114a and 114b, and perform matching adjustment.

[0042] As a configuration which both show to drawing 7 , matching circuits 107a and 107b consist of variable ceramic capacitor VC 1-521 and variable ceramic capacitor VC 2-522, drive these variable ceramic capacitors by the motor in driving gear 110a and 110b, and perform matching adjustment.

[0043] In this example of an experiment, matching adjustment by the matching control device 111 was performed by the approach explained below.

[0044] First, the 1st high-frequency power is supplied to electrode 109a from the 1st RF generator 105a with predetermined power, while the matching control unit 111 acts as the monitor of the reflective power of the 1st high-frequency power detected by power meter 115a, the signal which scans variable ceramic capacitor VC1 in matching circuit 107a is transmitted to driving gear 110a, and driving gear 110a which received the signal scans variable ceramic capacitor VC1 in matching circuit 107a. And memory of the VC1 active parameter from which the reflective power of the 1st high-frequency power of being detected by power meter 115a becomes the minimum is carried out, VC1 active-parameter transmission is carried out [aforementioned], and variable ceramic capacitor VC1 of matching circuit 107a is set as driving gear 110a.

[0045] Then, while the matching control unit 111 acts as the monitor of the reflective power of the 1st high-frequency

power of being detected by power meter 115a, the signal which scans variable ceramic capacitor VC2 in matching circuit ~~107a is transmitted to driving gear 110a, and driving gear 110a which received the signal scans variable ceramic~~ capacitor VC2 in matching circuit 107a. And memory of the VC2 active parameter from which the reflective power of the 1st high-frequency power of being detected by power meter 115a becomes the minimum is carried out, VC2 active-parameter transmission is carried out [aforementioned], and variable ceramic capacitor VC2 of matching circuit 107a is set as driving gear 110a.

[0046] By the above-mentioned approach, discharge is started by adjusting variable ceramic capacitors VC1 and VC2 by turns. If discharge is started, the 2nd high-frequency power will be supplied to electrode 109b from the 2nd RF generator 105b with predetermined power.

[0047] And while the matching control unit 111 acts as the monitor of the reflective power of the 2nd high-frequency power detected by power meter 115b, driving gear 110b which received delivery and a signal for the signal which scans variable ceramic capacitor VC1 in matching circuit 107b to driving gear 110b makes variable ceramic capacitor VC1 scan. And memory of the VC1 active parameter from which the reflective power of the 2nd high-frequency power detected by power meter 115b serves as the minimum is carried out, VC1 active-parameter transmission is carried out [aforementioned], and variable ceramic capacitor VC1 of matching circuit 107b is set as driving gear 110b.

[0048] Then, while the matching control unit 111 acts as the monitor of the reflective power of the 2nd high-frequency power of being detected by power meter 115b, driving gear 110b which received delivery and a signal for the signal which scans variable ceramic capacitor VC2 in matching circuit 107b to driving gear 110b makes variable ceramic capacitor VC2 scan. And memory of the VC2 active parameter from which the reflective power of the 2nd high-frequency power detected by power meter 115b serves as the minimum is carried out, said VC2 active parameter is transmitted to driving gear 110b, and variable ceramic capacitor VC2 of matching circuit 107b is set up.

[0049] The matching control unit 111 repeats the above-mentioned approach, tunes finely in order of VC1 in matching circuit 107a, VC2 in matching circuit 107a, VC1 in matching circuit 107b, VC2 in matching circuit 107b, VC1 in matching circuit 107a, and ..., and performs matching adjustment of both high-frequency power. Therefore, in this example of an experiment, while operating one of variable ceramic capacitors, other variable ceramic capacitors will be operated.

[0050] On the other hand, the comparison discharge experiment was conducted 30 times by the matching adjustment approach explained below using the equipment shown in drawing 8 . The difference between the equipment shown in drawing 8 and the equipment shown in drawing 1 is the point of having changed into the matching adjusting devices 111a and 111b which adjust independently each matching circuits 107a and 107b, respectively instead of the matching adjusting device 111 of a matching adjustment means.

[0051] First, the 1st high-frequency power is supplied to electrode 109a from the 1st RF generator 105a, while matching control unit 111a acts as the monitor of the reflective power of the 1st high-frequency power detected by power meter 115a, the signal which scans variable ceramic capacitor VC1 in matching circuit 107a is transmitted to driving gear 110a, and driving gear 110a which received the signal scans variable ceramic capacitor VC1 in matching circuit 107a. And memory of the VC1 active parameter from which the reflective power of the 1st high-frequency power detected by power meter 115a becomes the minimum is carried out, VC1 active-parameter transmission is carried out [aforementioned], and variable ceramic capacitor VC1 of matching circuit 107a is set as driving gear 110a.

[0052] Then, while matching control unit 111a acts as the monitor of the reflective power of the 1st high-frequency power of being detected by power meter 115a, the signal which scans variable ceramic capacitor VC2 in matching circuit 107a is transmitted to driving gear 110a, and driving gear 110a which received the signal scans variable ceramic capacitor VC2 in matching circuit 107a. And memory of the VC2 active parameter from which the reflective power of the 1st high-frequency power of being detected by power meter 115a becomes the minimum is carried out, VC2 active-parameter transmission is carried out [aforementioned], and variable ceramic capacitor VC2 of matching circuit 107a is set as driving gear 110a.

[0053] By the above-mentioned approach, discharge is started by adjusting variable ceramic capacitors VC1 and VC2 by turns. If discharge is started, the 2nd high-frequency power will be supplied to electrode 109b from the 2nd RF generator 105b with predetermined power.

[0054] After discharge is started, in matching control-device 111a, matching control-device 111b adjusts [b / matching circuit 107] to coincidence in quest of the point having consistency about matching circuit 107a.

[0055] That is, matching control unit 111b sets up the variable ceramic capacitors VC1 and VC2 of matching circuit 107b by turns so that the reflective power of the 2nd high-frequency power detected by power meter 115b may become the minimum, and performs matching adjustment at the same time matching control unit 111a sets up the variable ceramic capacitors VC1 and VC2 of matching circuit 107a by turns so that the reflective power of the 1st high-frequency power detected by power meter 115a may become the minimum. Therefore, the matching control units 111a and 111b are setup which adjusts two matching circuits by the concurrency independently, and control each matching circuit by this comparison discharge experiment regardless of the condition of the matching circuit of another side, and a matching

condition.

[0056]

[Table 1]

ガス種及び流量 SiH_4 [ml／min（normal）]	100
内圧　（Pa）	0.7
第１の高周波電源周波数　（MHz）	105
第２の高周波電源周波数　（MHz）	13.56
第１の高周波電力　（W）	450
第２の高周波電力　（W）	50
放電維持時間　（min）	20

[0057] The following concrete evaluation approaches and a valuation basis estimated this example of an experiment about "operability of matching actuation", and the "repeatability of matching conditions."
"Operability of matching actuation"
Time amount after starting the [evaluation approach] discharge until matching has consistency was measured, and it evaluated as what has high operability, so that matching could be adjusted for a short time. In addition, both judgments of matching adjustment were made on the time of the reflective power of two high-frequency power turning into 5% or less of incidence power. Moreover, when matching is not able to be taken in a charging time value, it is evaluating as time amount until it adjusts a charging time value.
[Valuation basis] To between mean times until it carries out matching adjustment, O and less than 90% 70% or more of case was evaluated for O and less than 70% 50% or more of case, and ** and 110% or more of case were evaluated [the case in this discharge experiment in 30 comparison discharge experiments where a mean time until it carries out matching adjustment was less than 50%] for O-** and less than 110% 90% or more of case as x.
"Repeatability of matching conditions"
The [evaluation approach] matching conditions were in the condition which matching during plasma production adjusts, calculated the electrostatic capacity of a total of four variable ceramic capacitors in two matching circuits for every discharge experiment, and evaluated it by the variation. When it judged that matching conditions are specifically reproduced when dispersion in all capacitor capacity is less than 5% and at least one shifted 5% or more among four variable ceramic capacitors, matching conditions were evaluated as what is not being reproduced.
O-** was evaluated for less than 130% O and 110% or more of case, and ** and less than 90% of case were evaluated [the case where the matching condition recall of this discharge experiment to the matching condition recall in a [valuation-basis] comparison discharge experiment was 150% or more / less than 150% O and 130% or more of case] for 90% or more as x less than 110%.
[0058] In this example of an experiment, the effectiveness the repeatability of O-** and matching conditions is O and this invention excelled [effectiveness] in the operability of matching actuation was checked.
(Example 2 of an experiment) In this example of an experiment, the discharge experiment was conducted 30 times on condition that Table 2 using the equipment of drawing 2 . The difference in the equipment configuration of this example of an experiment and the example 1 of an experiment is the point that power is supplied to the same electrode 209 from two RF generators 205a and 205b in this example of an experiment.
[0059] Like the example 1 of an experiment, as a configuration which both show to drawing 7 , matching circuits 207a and 207b consist of variable ceramic capacitor VC 1-521 and variable ceramic capacitor VC 2-522, drive these variable ceramic capacitors by the motor in driving gear 210a and 210b, and perform matching adjustment.
[0060] Matching adjustment by the matching control device 211 in this example of an experiment was performed by the approach explained below.
[0061] The 1st high-frequency power is supplied with predetermined power from the 1st RF generator 205a. First, the matching control unit 211 Detecting the reflective power of the 1st high-frequency power detected by power meter 215a Transmit the signal which makes driving gear 210a scan variable ceramic capacitor VC1 in matching circuit 207a, and driving gear 210a which received the signal scans variable ceramic capacitor VC1 in matching circuit 207a. Memory of the VC1 active parameter from which the reflective power of the 1st high-frequency power of being detected by power meter 215a serves as the minimum is carried out, said VC1 active parameter is transmitted to driving gear 210a, and variable ceramic capacitor VC1 in matching circuit 207a is set up.
[0062] Then, the matching control device 211 transmits the signal which scans variable ceramic capacitor VC2 in matching circuit 207a to driving gear 210a. Driving gear 210a which received the signal scans variable ceramic capacitor VC2 in matching circuit 207a. Memory of the VC2 active parameter from which the reflective power of the 1st high-frequency power detected by power meter 215a becomes the minimum is carried out, said VC2 active parameter is

transmitted to driving gear 210a, and variable ceramic capacitor VC2 in matching circuit 207a is set up.
[0063] Discharge is started by adjusting the variable ceramic capacitors VC1 and VC2 in the above-mentioned matching circuit 207a by turns. If discharge is started, the 2nd high-frequency power will be supplied to an electrode 209 with predetermined power from the 2nd RF generator 205b.
[0064] And the matching control device 211 transmits the signal which scans variable ceramic capacitor VC1 in matching circuit 207b to driving gear 210b. Driving gear 210b which received the signal scans variable ceramic capacitor VC1 in matching circuit 207b. The reflective power of the 2nd high-frequency power detected by power meter 215b goes to the minimum. And the reflective power of the 1st high-frequency power detected by power meter 215a carries out memory of the VC1 active parameter which maintains less than 30% to incidence power. VC1 active-parameter transmission is carried out [aforementioned], and variable ceramic capacitor VC1 in matching circuit 207b is set as driving gear 210b.
[0065] By the same approach, the matching control device 211 sets up variable ceramic capacitor VC2 in matching circuit 207b.
[0066] Furthermore, the matching control unit 211 repeats the above-mentioned approach, it tunes finely, supervising the reflective power of another side in order of VC1 in matching circuit 207a, VC2 in matching circuit 207a, VC1 in matching circuit 207b, VC2 in matching circuit 207b, VC1 in matching circuit 207a, and ..., and performs matching adjustment about both high-frequency power. Therefore, in this example of an experiment, while operating one of variable ceramic capacitors, other variable ceramic capacitors will be operated.
[0067] On the other hand, the same change as the equipment of drawing 8 which used the matching adjustment means of the equipment of drawing 2 in the comparison discharge experiment of the example 1 of an experiment was made, and the comparison discharge experiment was carried out 30 times with the same matching adjustment approach as the comparison discharge experiment of the example 1 of an experiment.
[0068]
[Table 2]

ガス種及び流量 ＳｉＨ$_4$ ［ｍｌ／ｍｉｎ（ｎｏｒｍａｌ）］	１００
基板温度　（℃）	２５０
内圧　（Ｐａ）	０．７
第１の高周波電源周波数　（ＭＨｚ）	１０５
第２の高周波電源周波数　（ＭＨｚ）	６０
第１の高周波電力　（Ｗ）	３５０
第２の高周波電力　（Ｗ）	１５０
放電維持時間　（ｍｉｎ）	２０

[0069] About 30 discharge experiments conducted in this example of an experiment, the same evaluation as the example 1 of an experiment was performed for the "operability of matching actuation", and the "repeatability of matching conditions" on the basis of the result of a comparison discharge experiment.
[0070] In this example of an experiment, the effectiveness the repeatability of O and matching conditions is O and this invention excelled [effectiveness] in the operability of matching actuation was checked.
(Example 3 of an experiment) In this example of an experiment, using the equipment of drawing 3 , the frequency ratio of two high-frequency power was variously changed, while it had been fixed, and it performed a total of 60 discharge experiments by a unit of 10 times about the combination of one frequency by the discharge conditions of Table 3.
[0071] The difference between the equipment used by this example, and the equipment of drawing 2 used in the example 2 of an experiment This example of an experiment is a plasma-CVD reaction container which performs plasma treatment to a cylindrical base, and supply the compound high-frequency power to the power branching plate 320, and it is impressed to four electrodes 309 connected to the power branching plate 320. It is the point changed into the reflected wave meter 315a and 315b which can detect the phase of a reflected wave [as opposed to an incident wave for a detection means to detect a matching condition as the point which introduces high-frequency power in the reaction container 301], and the amplitude of a reflected wave.
[0072] In addition, like the example 1 of an experiment, as a configuration which both show to drawing 7 , matching circuits 307a and 307b consist of variable ceramic capacitor VC 1-521 and variable ceramic capacitor VC 2-522, drive these variable ceramic capacitors by the motor in driving gear 310a and 310b, and perform matching adjustment.
[0073] The matching adjustment approach of this example of an experiment using above equipment is as follows.
[0074] The 1st high-frequency power is supplied to an electrode 309 with predetermined power from the 1st RF generator 305a. First, the matching control unit 311 Transmit the signal which scans the variable ceramic capacitors VC1 and VC2 in matching circuit 307a to driving gear 310a, and driving gear 310a which received the signal scans the

variable ceramic capacitors VC1 and VC2 in matching circuit 307a. The variable ceramic capacitors VC1 and VC2 in ~~matching circuit 307a are scanned detecting the phase to the incident wave of the reflected wave of the 1st high-~~ frequency power of being detected by reflected wave meter 315a, and the amplitude of the reflected wave of the 2nd high-frequency power. The active parameter of variable ceramic capacitor VC1 from which the gap of a phase to the incident wave of the reflected wave of the 1st high-frequency power detected by reflected wave meter 315a becomes the minimum, And memory of the active parameter of variable ceramic capacitor VC2 from which the amplitude of the reflected wave of the 1st high-frequency power detected by reflected wave meter 315a becomes the minimum is carried out. driving gear 310a -- said VC1 -- VC2 active-parameter transmission is carried out, the variable ceramic capacitors VC1 and VC2 in matching circuit 307a are set up, and discharge is started.

[0075] If discharge is started, the 2nd high-frequency power will be supplied to an electrode 309 with predetermined power from the 2nd RF generator 305b. The matching control unit 311 Transmit the signal which scans the variable ceramic capacitors VC1 and VC2 in matching circuit 307b to driving gear 310b, and driving gear 310b which received the signal scans the variable ceramic capacitors VC1 and VC2 in matching circuit 307b. The gap of a phase to the incident wave of the reflected wave of the 2nd high-frequency power detected by reflected wave meter 315b goes to the minimum. And the amplitude of the reflected wave of the 2nd high-frequency power detected by reflected wave meter 315b goes to the minimum. And the amplitude of the reflected wave of the 1st high-frequency power detected by reflected wave meter 315a carries out memory of the active parameter of variable ceramic capacitors VC1 and VC2 which maintains less than 30% to the amplitude of an incident wave. driving gear 310b -- said VC1 -- VC2 active-parameter transmission is carried out and the variable ceramic capacitors VC1 and VC2 in matching circuit 307b are set up.

[0076] Furthermore, the matching control unit 311 repeats the above-mentioned approach, tunes finely in order of VC1 and VC2 of matching circuit 317a, VC1 and VC2 of matching circuit 317b, VC1 and VC2 of matching circuit 307a, and ..., and performs matching adjustment about both high-frequency power. Therefore, in this example of an experiment, while operating one matching circuit, the matching circuit of another side will be operated.

[0077] On the other hand, the comparison discharge experiment was conducted a total of 60 times 10 times about the combination of each frequency by the matching adjustment approach explained below using the equipment shown in drawing 9 .

[0078] The 1st high-frequency power is supplied to an electrode 309 with predetermined power from the 1st RF generator 305a. First, matching control unit 311a Transmit the signal which scans the variable ceramic capacitors VC1 and VC2 in matching circuit 307a to driving gear 310a, and driving gear 310a which received the signal scans the variable ceramic capacitors VC1 and VC2 in matching circuit 307a. The variable ceramic capacitors VC1 and VC2 in matching circuit 307a are scanned detecting the phase to the incident wave of the reflected wave of the 1st high-frequency power detected by reflected wave meter 315a, and the amplitude of the reflected wave of the 1st high-frequency power. The active parameter of variable ceramic capacitor VC1 from which the gap of a phase to the incident wave of the reflected wave of the 1st high-frequency power detected by reflected wave meter 315a becomes the minimum, And memory of the active parameter of variable ceramic capacitor VC2 from which the amplitude of the reflected wave of the 1st high-frequency power detected by reflected wave meter 315a becomes the minimum is carried out. driving gear 310a -- said VC1 -- VC2 active-parameter transmission is carried out, the variable ceramic capacitors VC1 and VC2 in matching circuit 307a are set up, and discharge is started.

[0079] After starting discharge, the 2nd high-frequency power is supplied to an electrode 309 with predetermined power from the 2nd RF generator 305b. Matching control unit 311a Based on the detection result of reflected wave meter 315a, to adjusting the variable ceramic capacitors VC1 and VC2 in matching circuit 307a, and coincidence, matching control unit 311b Based on the detection result of reflected wave meter 315b, the variable ceramic capacitors VC1 and VC2 in matching circuit 307b are adjusted, and matching adjustment is performed about both high-frequency power. Therefore, it is a setup which adjusts each matching circuit by the concurrency, and the condition of the matching circuit of another side and a matching condition are not related, and each matching circuit is controlled by this example of comparative experiments.

[0080]

[Table 3]

ガス種及び流量 SiH_4 [ml/min (normal)]	100
基板温度 (℃)	250
内圧 (Pa)	10
第1の高周波電源周波数f1 (MHz)	10～300 ※1
第2の高周波電源周波数f2 (MHz)	f1の0.6倍
第1の高周波電力P1 (W)	250
第2の高周波電力P2 (W)	250
放電維持時間 (min)	20

※1 表4を参照

[0081] About 30 discharge experiments conducted in this example of an experiment, the same evaluation as the example 1 of an experiment was performed for the "operability of matching actuation", and the "repeatability of matching conditions" on the basis of the result of a comparison discharge experiment. An evaluation result is shown in Table 4.
[0082]
[Table 4]

周波数f1 (MHz	10	60	100	200	250	300
マッチング操作の操作性	○～△	○	◎	◎	○	○～△
マッチング条件の再現性	○	○	◎	○	○	○

[0083] (Example 4 of an experiment) Using the equipment of drawing 3 , this example of an experiment fixed the oscillation frequency f1 of 1st RF generator 305a to 250MHz between two high-frequency power, changed variously only the oscillation frequency f2 of 2nd RF generator 305b, and performed a total of 60 discharge experiments by a unit of 10 times about the combination of one frequency.
[0084] In addition, the matching adjustment approach of this example of an experiment is as follows.
[0085] The 1st high-frequency power is supplied to an electrode 309 with predetermined power from the 1st RF generator 305a. First, next, the matching control unit 311 The signal which scans the variable ceramic capacitors VC1 and VC2 in matching circuit 307a is transmitted to driving gear 310a. While driving gear 310a which received the signal detects the phase to the incident wave of the reflected wave of the 1st high-frequency power of being detected by reflected wave meter 315a, and the amplitude of the reflected wave of the 1st high-frequency power, the variable ceramic capacitors VC1 and VC2 in matching circuit 307a are scanned. The active parameter of variable ceramic capacitor VC1 from which the gap of a phase to the incident wave of the reflected wave of the 1st high-frequency power detected by reflected wave meter 315a becomes the minimum, And memory of the active parameter of variable ceramic capacitor VC2 from which the amplitude of the reflected wave of the 1st high-frequency power detected by reflected wave meter 315a becomes the minimum is carried out. Said VC1 and VC2 active parameter are transmitted to driving gear 310a, the variable ceramic capacitors VC1 and VC2 in matching circuit 307a are set up, and discharge is started.
[0086] If discharge is started, the 2nd high-frequency power will be supplied to an electrode 309 with predetermined power from the 2nd RF generator 305b. The matching control unit 311 The signal which scans the variable ceramic capacitors VC1 and VC2 in matching circuit 307b is transmitted to driving gear 310b. Gap of the phase of the reflected wave to the incident wave of the 2nd high-frequency power with which driving gear 310b which received the signal is detected by reflected wave meter 315b goes to the minimum. And the amplitude of the reflected wave of the 2nd high-frequency power detected by reflected wave meter 315b carries out memory of the active parameter of the variable ceramic capacitors VC1 and VC2 which go to the minimum. driving gear 310b -- said VC1 -- VC2 active-parameter transmission is carried out and the variable ceramic capacitors VC1 and VC2 in matching circuit 307b are changed. Furthermore, variable ceramic capacitor VC2 in matching circuit 307a is amended for a changed part of the amplitude of the reflected wave of the 1st high-frequency power which amends a changed part of the phase of the reflected wave to the incident wave of the 1st high-frequency power detected by reflected wave meter 315a adjustable and by controlling, and is detected [part] by reflected wave meter 315a in variable ceramic capacitor VC1 in matching circuit 307a adjustable and by controlling with this actuation.
[0087] In this way, the matching control unit 311 repeats the above-mentioned approach, performs fine tuning and matching condition amendment of the power of another side in order of VC1 and VC2 of matching circuit 317a, VC1 and VC2 of matching circuit 317b, VC1 and VC2 of matching circuit 307a, and ..., and performs matching adjustment about

both high-frequency power. Therefore, in this example of an experiment, matching adjustment will be performed by adjusting each matching circuit by turns, amending gap of matching of the high-frequency power of another side by adjusting one matching circuit in the matching circuit of another side.

[0088] In addition, using the same equipment as the example of a comparison discharge experiment of the example 3 of an experiment, a comparison discharge experiment is the same matching adjustment approach, and was conducted a total of 60 times by a unit of 10 times about the combination of each frequency.

[0089]

[Table 5]

ガス種及び流量 SiH_4 [ml／min（normal）]	100
基板温度 （℃）	250
内圧 （Pa）	1.0
第１の高周波電源周波数ｆ１ （MHz）	250
第２の高周波電源周波数ｆ２ （MHz）	6～180 ※2
第１の高周波電力Ｐ１ （W）	250
第２の高周波電力Ｐ２ （W）	250
放電維持時間 （min）	20

※２ 表６を参照

[0090] About 30 discharge experiments conducted in this example of an experiment, the same evaluation as the example 1 of an experiment was performed for the "operability of matching actuation", and the "repeatability of matching conditions" on the basis of the result of a comparison discharge experiment. An evaluation result is shown in Table 6.

[0091]

[Table 6]

周波数ｆ２（MHz）	6	36	60	120	150	180
マッチング操作の操作性	○～△	○	○	◎	◎	◎
マッチング条件の再現性	○～△	○	◎	◎	○	○

[0092]

[Example] Although an example explains this invention below, thereby, this invention is not restricted at all.

(Example 1) In this example, using the deposition film formation equipment shown in drawing 5 , the oscillation frequency of 1st RF generator 405a was set to 81MHz, and a total of 30 a-Si system photo conductors which consist of a charge impregnation blocking layer, a photoconduction layer, and a surface layer on the conditions which show the oscillation frequency of 2nd RF generator 405b in Table 7 on 13.56MHz conditions on the cylindrical base 402 with a diameter [of 80mm] and a die length of 358mm made from aluminum was produced 5 lots.

[0093] RF electrode 409 is a cylinder made from SUS304, and is installed in outside same periphery good spacing of the reaction container 401 made from an alumina. By blasting, the wall of the reaction container 401 made from an alumina set surface roughness to 20 micrometers by Rz which makes 2.5mm criteria length. Six cylindrical bases 402 are held at the base base material 416 which the material gas supply pipe 412 was installed in the reaction container 401 at the core, and was installed by the pivotable revolving shaft 417 arranged at equal intervals on the concentric circle periphery centering on the material gas supply pipe 412.

[0094] The high-frequency power outputted from RF generators 405a and 405b Matching circuits 407a and 407b are respectively supplied by the separate coaxial track 408. It is compounded after taking matching within matching circuit 407a and 407b, and the core of the power branching plate 420 is supplied, RF electrode 409 connected at equal intervals on the same periphery from the core of the power branching plate 420 is supplied, and it is introduced into the reaction container 401 from RF electrode 409.

[0095] In addition, between matching circuits 407a and 407b and each RF generators 405a and 405b, the filter circuit (un-illustrating) is prepared so that the high-frequency power of another side may not flow in.

[0096] The base base material 416 with which the cylindrical base 402 is laid is a product made from aluminum, and, as for the front face, blasting is performed. The cylindrical base 402 is laid in the center of the base base material 416.

[0097] The material gas supply pipe 412 has the structure where are a pipe made from an alumina and the closure of

the edge was carried out, and the thing of the structure which can supply material gas from the gas port prepared on the pipe was used. The front face of the material gas supply pipe 412 set surface roughness to 20 micrometers by blasting by the ten-point average of roughness height (Rz) which makes 2.5mm criteria length.
[0098] The photo conductor production procedure was carried out as follows [an outline].
[0099] First, the cylindrical base 402 held at the base base material 416 was installed on the revolving shaft 417 in the reaction container 401. Then, the inside of the reaction container 401 was exhausted through the exhaust pipe arrangement 413 with the exhaust air pump 404. Then, a heating process is performed. The cylindrical base 402 was rotated at the rate of 10rpm by the motor 419 through the revolving shaft 417, the cylindrical base 402 was heated and controlled by the heating element (un-illustrating) at 250 degrees C, supplying Ar of 500 ml/min. (normal) into the reaction container 401 through the material gas supply pipe 412 further, and the condition was maintained for 2 hours.
[0100] Subsequently, a deposition film formation process is performed. After suspending supply of Ar and exhausting the reaction container 401 through an exhaust pipe arrangement 413 with the exhaust air pump 404, the material gas used for the charge impregnation blocking layer formation shown in Table 7 through the material gas supply pipe 412 with a material gas supply means was introduced. The flow rate of material gas turned into a setting flow rate, after checking that the pressure in the reaction container 401 had been stabilized, high-frequency power with an oscillation frequency of 81MHz was impressed to RF electrode 409 through matching circuit 407a from RF generator 405a, and discharge was started by performing matching adjustment. After starting discharge, the charge impregnation blocking layer was deposited on the cylindrical base 402 by supplying high-frequency power with an oscillation frequency of 13.56MHz to RF electrode 409 through matching circuit 407b, generating the plasma, and carrying out excitation dissociation of the material gas from RF generator 405b. After formation of predetermined thickness was performed, supply of high-frequency power was stopped, supply of material gas was suspended continuously, and formation of a charge impregnation blocking layer was finished. Sequential formation of a multiple-times repeat, a photoconduction layer, and the surface layer was carried out for the same actuation. In addition, the same adjustment approach as the example 3 of an experiment was used for the matching adjustment approach of this example.
[0101]
[Table 7]

	電荷注入阻止層	光導電層	表面層
ガス種及び流量			
SiH_4 (ml/min (normal))	200	300	20
H_2 (ml/min (normal))	200	100	
B_2H_6 (ppm) SiH_4に対し	1000	1.2	
CH_4 (ml/min (normal))			50
NO (ml/min (normal))	10		
基板温度 (℃)	250	250	250
内圧 (Pa)	1.3	1.3	1.5
105MHz高周波電力 (W)	630	1260	350
60MHz高周波電力 (W)	270	540	350
膜厚 (μm)	3	30	0.5

[0102] In actual photo conductor production by the above-mentioned approach, matching adjustment was performed promptly, and each lot-to-lot matching conditions were reproduced highly, and the effectiveness of this invention was checked.
[0103] Moreover, the produced a-Si system photo conductor was installed in Canon 6750 [copying machine NP-] converted into this test, and the following concrete appraisal methods [items / of the "electrification ability" of a photo conductor, "the bus-bar nonuniformity of electrification ability", "sensibility" and "the bus-bar nonuniformity of sensibility" / four] estimated each item.
"Electrification ability" - "the bus-bar nonuniformity of electrification ability"
The umbra potential in the development counter location when passing a fixed current in the main electrification vessel of a copying machine is measured. Therefore, it is shown that electrification ability is so good that umbra potential is large. Electrification ability measurement was crossed to the direction of photo conductor bus-bar all field, and was

performed, and the average umbra potential estimated "electrification ability." Moreover, the difference of the highest umbra potential in a direction of photo conductor bus-bar all field and the minimum umbra potential was searched for, and "the bus-bar nonuniformity of electrification ability" was evaluated from this value.
"Sensibility" - "the bus-bar nonuniformity of sensibility"
After adjusting the main electrification machine current so that the umbra potential in a development counter location may become fixed, a 0.1 or less reflection density predetermined blank paper is used for a manuscript, and the image exposure quantity of light estimates that the bright section potential in a development counter location becomes a predetermined value. Therefore, it is shown that sensibility is so good that there is little image exposure. The sensitometry was crossed to the direction of photo conductor bus-bar all field, was performed, and evaluated "sensibility" by the average image exposure quantity of light. Moreover, the difference of the maximum image exposure quantity of light in a direction of photo conductor bus-bar all field and the minimum image exposure quantity of light was searched for, and this value estimated "the bus-bar nonuniformity of sensibility."
[0104] The variation in the "electrification ability" of all the produced photo conductors and "sensibility" was small, the height of vacuum processing repeatability became clear, "the bus-bar nonuniformity of electrification ability" and "the bus-bar nonuniformity of sensibility" were small, the matching adjustment at the time of plasma treatment was made the optimal, and became clear [the height of vacuum processing homogeneity], and the effectiveness which was excellent in this invention was checked.
(Example 2) In this example, the a-Si system photo conductor which consists of a charge impregnation blocking layer, a photoconduction layer, an up charge impregnation blocking layer, and a surface layer on the conditions shown in Table 8 was produced using the same equipment as an example 1 in five lots and the same procedure as a total of 30. In addition, the oscillation frequency of 105MHz and 2nd RF generator 405b was set to 50MHz for the oscillation frequency of 1st RF generator 405a. Moreover, the matching adjustment approach of this example also adopted the same adjustment approach as the example 3 of an experiment.
[0105]
[Table 8]

	電荷注入阻止層	光導電層	上部電荷注入阻止層	表面層
ガス種及び流量				
SiH_4 (ml/min (normal))	200	300	40	20
H_2 (ml/min(normal))	200	100		
B_2H_6 (ppm) SiH_4に対し			1000	
CH_4 (ml/min (normal))			10	50
NO(ml/min(normal))	15			
基板温度 (℃)	250	250	250	250
内圧 (Pa)	1.3	1.3	1.5	1.5
105MHz高周波電力 (W)	630	1260	350	350
60MHz高周波電力 (W)	270	540	350	350
膜厚 (μm)	3	30	0.5	0.5

[0106] In actual photo conductor production by the above-mentioned approach, matching adjustment was performed promptly, and each lot-to-lot matching conditions were reproduced highly, and the effectiveness of this invention was checked.
[0107] Moreover, the produced a-Si system photo conductor was installed in Canon 6750 [copying machine NP-] converted into this test, and it evaluated about four items of the "electrification ability" of a photo conductor, "the bus-bar nonuniformity of electrification ability", "sensibility", and "the bus-bar nonuniformity of sensibility" as well as an example 1.
[0108] Consequently, the variation in the "electrification ability" of all the photo conductors produced by this example and "sensibility" was small, the height of vacuum processing repeatability became clear, "the bus-bar nonuniformity of electrification ability" and "the bus-bar nonuniformity of sensibility" were small, the matching adjustment at the time of plasma treatment was made the optimal, and became clear [the height of vacuum processing homogeneity], and the effectiveness which was excellent in this invention was checked.

(Example 3) In this example, a total of ten a-Si system photo conductors which consist the oscillation frequency of 1st RF generator 305a of a charge impregnation blocking layer, a photoconduction layer, and a surface layer in the oscillation frequency of 105MHz and 2nd RF generator 305b on the conditions shown in Table 9 on 60MHz conditions on the cylindrical base 302 with a diameter [of 80mm] and a die length of 358mm made from aluminum was produced 10 lots using the deposition film formation equipment shown in drawing 3 .
[0109] The difference between the equipment of this example and the equipment of drawing 4 used in the example 1 is that arrange the cylindrical base 302 at the core in the reaction container 301 made from aluminum of a cylindrical shape, and RF electrode 309 and the material gas supply pipe 312 are arranged inside a reaction container at equal intervals on the same periphery centering on a cylindrical base. Moreover, the wall of the reaction container 301 made from aluminum set surface roughness to 20 micrometers by blasting by Rz which makes 2.5mm criteria length.
[0110] The high-frequency power outputted from RF generators 305a and 305b Matching circuits 307a and 307b are respectively supplied by the separate coaxial track 308. After taking matching within matching circuit 307a and 307b, it is compounded, the core of the power branching plate 320 is supplied, RF electrode 309 connected to the same periphery good spacing from the core of the power branching plate 320 is supplied, and it is directly introduced into the reaction container 301 from RF electrode 309. In addition, between matching circuits 307a and 307b and each RF generators 305a and 305b, the filter circuit (un-illustrating) is prepared so that the high-frequency power of another side may not flow in.
[0111] The photo conductor production procedure performed deposition film formation in order of the charge impregnation blocking layer, the photoconduction layer, and the surface layer on the conditions shown in the same heating process and same Table 9 as an example 1. In addition, the same adjustment approach as the example 4 of an experiment was used for the matching adjustment approach of this example.
[0112]
[Table 9]

	電荷注入阻止層	光導電層	表面層
ガス種及び流量			
SiH_4 (ml/min (normal)	100	100	15
H_2 (ml/min (normal))	50	50	
B_2H_6 (ppm)			
SiH_4に対し	1000	1.2	
CH_4 (ml/min (normal))			30
NO (ml/min (normal))	10		
基板温度 (℃)	250	250	250
内圧 (Pa)	1.3	1.3	1.5
105MHz高周波電力 (W)	420	840	300
60MHz高周波電力 (W)	180	360	300
膜厚 (μm)	3	30	0.5

[0113] In actual photo conductor production by the above-mentioned approach, matching adjustment was performed promptly, and each lot-to-lot matching conditions were reproduced highly, and the effectiveness of this invention was checked.
[0114] Moreover, the produced a-Si system photo conductor was installed in Canon 6750 [copying machine NP-] converted into this test, and evaluation of four items of the "electrification ability" of a photo conductor, "the bus-bar nonuniformity of electrification ability", "sensibility", and "the bus-bar nonuniformity of sensibility" was performed like the example 1.
[0115] Consequently, the variation in the "electrification ability" of all the photo conductors produced by this example and "sensibility" was small, the height of vacuum processing repeatability became clear, "the bus-bar nonuniformity of electrification ability" and "the bus-bar nonuniformity of sensibility" were small, the matching adjustment at the time of plasma treatment was made the optimal, and became clear [the height of vacuum processing homogeneity], and the effectiveness which was excellent in this invention was checked.
[0116]
[Effect of the Invention] In the vacuum art which according to this invention installs a processed material in the reaction container which can be decompressed, introduces material gas, generates the plasma of this material gas with high-frequency power, and processes this processed material as explained above Supply two or more high-frequency power to an electrode through a separate matching circuit, detect any they are as there being few conditions of the matching

circuit and matching conditions of high-frequency power, and a detection result is fed back. It was effective in compaction of improvement in the operability of a matching adjustment means, improvement in the repeatability of matching conditions, and the adjustment time amount of matching being attained by adjusting two or more matching circuits.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the mimetic diagram of the parallel monotonous plasma treatment equipment of the gestalt of the 1st operation which applied this invention.
[Drawing 2] It is the mimetic diagram of the parallel monotonous plasma treatment equipment of the gestalt of the 2nd operation which applied this invention.
[Drawing 3] It is the mimetic diagram of the deposition film formation equipment for cylindrical bases of the gestalt of the 3rd operation which applied this invention.
[Drawing 4] It is the typical flat-surface sectional view of the deposition film formation equipment for cylindrical bases of the gestalt of the 3rd operation which applied this invention.
[Drawing 5] It is the mimetic diagram of the deposition film formation equipment for cylindrical bases of the gestalt of the 4th operation which applied this invention.
[Drawing 6] It is the typical flat-surface sectional view of the deposition film formation equipment for cylindrical bases of the gestalt of the 4th operation which applied this invention.
[Drawing 7] It is the mimetic diagram of a matching circuit used for the example of an experiment, and the example.
[Drawing 8] It is the mimetic diagram of the parallel monotonous plasma treatment equipment used for the comparison discharge experiment of the example 1 of an experiment.
[Drawing 9] It is the mimetic diagram of the deposition film formation equipment for cylindrical bases used for the comparison discharge experiment of the examples 3 and 4 of an experiment.
[Description of Notations]
101,201,301 401 Reaction container
102,202 Substrate
302,402 Cylindrical base
103,203,303 403 Material gas feeder
104,204,304 404 Exhaust air pump
105a, 105b, 205a, 205b, 305a, 305b, 405a, 405b, 505 RF generator
106 206,306,406,506 Matching adjustment means
107a, 107b, 207a, 207b, 307a, 307b, 407a, 407b, 507 Matching circuit
108a, 108b, 208,308,408 Coaxial track
109,209,309,409 Electrode
110a, 110b, 210a, 210b, 310a, 310b, 410a, 410b Driving gear
111, 211,311,411,111a, 111b, 311a, a 311b matching control unit
112,212,312 412 Material gas supply pipe
113,213,313,413 Exhaust pipe arrangement
114a, 114b, 214a, 214b, 314a, 314b, 414a, 414b Directional coupler
115a, 115b, 215a, 215b Power meter
315a, 315b, 415a, 415b Reflected wave meter
316,416 Base base material
317,417 Revolving shaft
318,418 Reduction gear
319,419 Motor
320,420 Power branching plate
421 RF Shielding Container
521 Variable Ceramic Capacitor VC1
522 variable-ceramic-capacitor VC2